Report on the Work on the Decomposition of Green and Organic Manures.

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AT the last Agricultural Conference a paper was read on the results obtained up to that time, of experiments that had been, started in Dec., 1925, on the decomposition of green and organic manures under Peradeniya conditions. These investigations have since been extended, thus necessitating their continuation for a further period of two years. In this paper I propose briefly to outline the progress made with these experiments and the more important conclusions that have been drawn from them.

Green Manure Experiments.—Laboratory and field experiments were started simultaneously in December, 1925, to study the rates of decomposition from the nitrogen standpoint, of the more widely-grown leguminous crops, viz., Dadaps, *Gliricidia*, *Boga medeloa*, *Albizzia* and *Crotalaria anagyroides*. For purposes of comparison a non-leguminous crop, viz., Wild sunflower and cattle manure were also included in the series. In the laboratory experiments the green manures were incorporated with the soil at the rate of 1 gm. of green manure to 100 gm. of dry soil. In the field series green manures at the rate of 2 cwt. per plot or 10 tons per acre were envelope-forked into the soil. The field experiments were carried out on a block of forty plots each 1/100th of an acre in extent, composed of five plots for each of the green manures and cattle manure and five controls. The field experiments were discontinued in August, 1926, as they had served the purpose for which they had been started. The laboratory experiments so far as they went, confirmed fully the results of the field experiments. The following conclusions have been drawn from these experiments.

(1) Maximum nitrate accumulation or " nitrification " in the soil resulting from green-manuring takes place between the 6th and 8th week after the burial of the green material. The field experiments further demonstrate that nitrification takes place subsequent to this, but to a lesser extent, and that after the 5th or 6th month the direct effects of green manuring from the nitrogen standpoint are hardly appreciable. A glance at the figure will show this clearly. It would thus appear that under estate conditions it would be preferable to green-manure at shorter intervals say, *e.g.*, at least twice a year and in smaller quantities than at longer intervals and with larger amounts of green material.

(2) The amounts of nitrate present in the soil at any particular time in the green manure plots is dependent on the rainfall during the previous fortnight. As the rainfall increases the nitrate content falls and *vice versa*. The low nitrate content is probably due to (1) the washing away of the nitrate to the lower layers of soil (2) excessive moisture which is detrimental to bacterial action. The temperature curve is noted to follow the nitrate curve.

(3) As regards individual leguminous green manures Dadaps and *Gliricidia* give highest nitrification percentages for Peradeniya conditions. It is obvious however that individual results would be conditioned by the nitrogen content of the buried material, the proportion of leaf to stem, age of material, etc.

(4) The use of non-leguminous leafy material, *e.g.* Wild Sun-flower resulted in as great an accumulation of nitrate in the the soil as when leguminous crops were used.

(5) The cattle manure plots show hardly any increase of nitrate over the controls. This is due to the low nitrogen content of the sample.

In this series of field experiments, the green material buried in the soil was grown elsewhere. A second series of field experiments have been started in co-operation with the Manager of the Experiment Station, Peradeniya, in December, 1926, in which the green manures are grown *in situ*, viz., on the plots into which they are to be forked in. Experiments are to be carried out with the three classes of green manures—the tree, shrubby and creeping forms. In half the number of plots the green manures are to be periodically cut and buried in, and in the other half the green manures are to be allowed their normal growth. These experiments should give an idea of the amounts of nitrogen fixed in the soil by leguminous crops, apart from the additional quantities produced as a result of burying them in.

Organic Manure Experiments.—The first series of laboratory experiments with organic manures were carried out in the same manner as the experiments with green manures. The organic manures were added at the rate of 1 per cent. of the weights of soil. The addition of such large quantities of green manures was found to result in the nitrification of only small percentages of the *added* nitrogen, varying from 11·5 to 16 per cent. These experiments however demonstrate that unless an adequate amount of moisture is present in the soil—viz., $\frac{3}{8}$ to $\frac{1}{2}$ of the saturation moisture content of the soil—optimum nitrification will not take place. In the second series of laboratory experiments, therefore, the manures were incorporated with the soil in quantities proportionate to 5 cwt. of manure per acre and the series extended to include inorganic nitrogenous manures as well, viz.,

Sulphate of Ammonia and Calcium Cyanamide. The effects of lime on the nitrification of an organic manure, viz., Blood Meal, and the effects on nitrification of sterilising the soil with steam at 120° C for ½ an hour were also determined.

The results of these experiments demonstrate:—

(1) That maximum nitrification takes place between the 4th and 8th weeks in the case of most of these manures; and that the less nitrogenous manures attain maximum nitrification sooner than the more nitrogenous ones. In other words the effects of more nitrogenous manures last longer in the soil than those of the less nitrogenous ones.

(2) The nitrification percentages in the case of most of the manures used varied from 85 to 90 per cent. Blood Meal gave 50 per cent. nitrification. Castor Cake and Crushed Fish showed only 20 per cent. nitrification. It is probable that maximum nitrification in the case of these manures was reached some time between the 4th and 6th week, at which time owing to sampling being done once a fortnight, no sampling was made. I would wish therefore to emphasise that the nitrification figures for these two manures should not be regarded as correctly representing their nitrogen availabilities until the results of further experiments with these, to be carried out shortly, are obtained.

(5) The curve for the control clearly shows that large amounts of nitrate are fixed in soil by the nitrogen fixing bacteria or Azotobacter as they are called, provided that proper moisture and cultivation conditions are maintained. The amount present in the control plot at one sampling was 4·5 mgm. nitrate nitrogen per 100 gm. of dry soil. When one realises that 1 mgm. of nitrogen per 100 gm. of any soil is equivalent to about 25 lb. per acre, and therefore 4·5 mgm. to 112 lb. nitrate nitrogen, the advantages of soil cultivation alone are apparent. That the *Azotobacter* are the agents at work in nitrate formation is proved by the pots which had been steam sterilised and treated with manure. No nitrate was found in them even after two months. The sterilization had killed off all the beneficial nitrogen-fixing organisms.

(6) The effect of lime in accelerating and increasing nitrification is evident from the curve. This large nitrate-formation is due to the mineralization of the humus nitrogen of the soil by the lime and, according to Löhnis, to the increased activities of the micro-organisms of the soil as a result of such an application.

(7) The nitrate curve illustrates the general law of limiting factors. A steady increase is first observed. The curve then remains constant at its maximum and subsequently falls. This fall may be due either to nitrate-destroying or to nitrate-accumulating bacteria. The fall is observed in all cases about the 14th

week, but is followed by a rise even higher than the maximum obtained previously. The reason for this is not quite apparent. The explanation may however be put forward, as suggested by Russell and Richards, that the nitrate-accumulating micro-organisms which were functioning during the period of the decline in the nitrate curve liberated their nitrate at this period, or having died off, their bodies decomposed again with the formation of nitrates.

These laboratory experiments have been followed up by field experiments with these manures started in December, 1926. Unfortunately owing to the unusual rainfall conditions prevalent, in nearly all cases rain having fallen just prior to sampling, the nitrate formed had all washed out of the upper layers of soil, and hence but little conclusive data have so far been obtained. What has however been established by this series of field experiments as with the field green manure experiments is that the amount of nitrate present in the soil at any particular time as a result of manuring is dependent on the rainfall prevalent during the previous fortnight. These experiments are to be continued during the whole of this year, at the end of which time some conclusive data can be expected.

Discussion.

HIS EXCELLENCY THE GOVERNOR in congratulating Mr. Joachim on his interesting paper remarked that he understood Mr. Joachim to say that he recommended more frequent manuring and in smaller quantities. Were the figures for cost gone into?

MR. JOACHIM replied that no figures for cost had been gone into.

MR. GEORGE BROWN said that Mr. Joachim did not tell them in what month of the year these experiments were carried out.

Mr. JOACHIM said that these experiments were started in December and were continued for nine months to see how long the effects of green manure would last.

DR. RAJASINGHAM remarked that in the case of human beings though leguminous food stuffs such as dhall, etc., contained high percentages of proteins, still the system assimilated little as compared to meat. He wished to know if the same thing happened in the case of leguminous crops in the soil. Though containing high percentages of nitrogen did they give the same amount of nitrates as non-leguminous crops.

MR. JOACHIM said that though leguminous plants generally contained higher percentages of nitrogen than non-leguminous plants, that was not always so. In the case of these experiments the percentage of nitrogen was about the same in both leguminous and non-leguminous crops.

MR. NEWTON asked how long after cutting the plants were buried and whether drying in the sun resulted in a loss of nitrogen. He wished to know whether it was preferable to bury green or to allow a certain amount of drying.

MR. JOACHIM said that the plants were buried soon after cutting and that drying did not lower the percentage of nitrogen in the crop but the amount nitrified in the soil.

MR. JOHN HORSFALL inquired whether half saturation gave maximum nitrification results and also wished to know what half saturation represented in rainfall.

MR. JOACHIM said that maximum nitrification was obtained with either $\frac{3}{8}$th or $\frac{1}{2}$ saturation. This latter figure would vary with different types of soils.

MR. H. W. ROY BERTRAND said that his field experiments did not show the secondary effects of organic manures in soils.

MR. JOACHIM replied that these experiments were carried out under laboratory conditions and there was therefore no loss of nitrate due to leaching, which would be the case in the field, so that there would be no secondary effect in all probability.

MR. CARSON PARKER inquired whether any experiments in nitrification were carried out with Oxalis.

THE DIRECTOR OF AGRICULTURE replied that no such experiments had been carried out. He also stated that it was generally considered advisable in dealing with green manures and cover crops to bury the material green and not allow it to dry before burial.

HIS EXCELLENCY THE GOVERNOR in concluding the discussion said that he listened with great interest to the account of Mr. Joachim's experiments and also the readiness with which Mr. Joachim had replied to the various conundrums put by the gentlemen present.